NASA TECHNICAL TRANSLATION NASA TT F-15,538

TEST STANDS FOR STUDYING TECHNOLOGICAL PROCESSES UNDER SIMULATED SPACE CONDITIONS

B. Ye. Paton, D. A. Dudko, V. N. Bernardskiy,
V. F. Lapchinskiy, V. V. Stesin, A. A. Zagrebel'nyy
and O. S. Tsygankov

(NASA-TT-F-15538) TEST STANDS FOR STUDYING TECHNOLCGICAL PROCESSES UNDER SIMULATED SPACE CONDITIONS (Kanner (Leo) Associates) 12 p HC $4.00 CSCL 14B G3/11

N74-21897

Unclas
36844

Translation of "Stendy dlya issledovaniya tekhnologicheskikh protesessov v usloviyakh, imitiruyushchikh kosmos," Paper delivered at the 24th International Astronautical Congress, Baku, Azerbaydzhan SSSR, October 7-13, 1973, 12 pages

MAY 1974
RECEIVED
NASA STI FACILITY
INPUT BRANCH

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546 APRIL 1974

STANDARD TITLE PAGE

1. Report No. NASA TT F-15,538	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle TEST STANDS FOR STUDYING TECHNOLOGICAL PROCESSES UNDER SIMULATED SPACE CONDITIONS		5. Report Date April 1974
		6. Performing Organization Code
7. Author(s) B.Ye. Paton, D. A. Dudko, V.N. Bernardskiy, V. F. Lapchinskiy, V.V. Stesin, A. A. Zagrebel'nyy, and O. S. Tsygankov, Academy of Sciences of the Ukrainian SSR, Kiev)		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address Leo Kanner Associates Redwood City, California 94063		11. Contract or Grant No. NASw-2481
		13. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration, Washington, D.C. 20546		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Stendy dlya issledovaniya tekhnologicheskikh protsessov v usloviyakh, imitiruyushchikh kosmos," Paper delivered at the 24th International Astronautical Congress, Baku, Azerbaydzhan SSSR, October 7-13, 1973, 12 pages

16. Abstract

Review of equipment designed for use in experiments with technological operations on board of spacecraft during Soviet manned space missions. Experiments with molten metal on Soyuz 6 in October 1969 are indicated as an example of such operations. Particular attention is given to the difficulties encountered in simulation of the various adverse forces and factors which must be dealt with and counteracted during the performance of industrial work in a space environment. Investigations showed that the best space vacuum simulation could be achieved in large vacuum chambers whose dimensions match those of the equipment to be simulated and tested. Several test stands developed in the Soviet Union for this purpose are described.

N A74-12844

17. Key Words (Selected by Author(s))	18. Distribution Statement Unclassified-Unlimited

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 12	22. Price 4.00

NASA-HQ

TEST STANDS FOR STUDYING TECHNOLOGICAL PROCESSES UNDER SIMULATED SPACE CONDITIONS

B. Ye. Paton, D. A. Dudko, V. N. Bernardskiy,
V. F. Lapchinskiy, V. V. Stesin, A. A. Zagrebel'nyy
and O. S. Tsygankov,
Academy of Sciences of the Ukrainian SSR, Kiev

The ever increasing front of space research is progressing, /1*
and one of the most important tasks is to carry out in space various technological operations (for example, the fusion of metals, the casting of various components, welding, metal spray coating, the growing of monocrystals). This work is particularly important at the present time, when space research has begun by using orbital research laboratories. These technological processes can be specifically used when carrying out repair and assembly work and obtaining various material in space.

The first experiments in working with molten metal in space were carried out in the Soviet Union, in October 1969 on the Soyuz-6 manned spacecraft by V. N. Kubasov and G. A. Shonin.

These experiments were preceded by lengthy research work on earth, during the process of which, various types of equipment and technology were tested. The experience which we accumulated during this work is briefly described in this report.

It is common knowledge that carrying out any experiment in space is a time-consuming, laborious and extremely expensive business. Therefore, it is recommended to carry out as much preparatory work as possible on earth. This approach makes it possible to prepare the experiment in space so as to avoid errors and complete it successfully. Everything which has been said is

---

* Numbers in the margin indicate pagination in the foreign text.

also true for preparing and conducting technological experiments. Therefore, in this work, we found that it was necessary to build special test stands, which made it possible, to some degree, to simulate space conditions before a space flight. /2

The better the preparation on the ground, the better it is to simulate a large number of factors which exist in space simultaneously. For carrying out technological work with molten metal, the basic factors are a high vacuum with extremely high evacuation rate of gases (diffusion), weightlessness, a wide temperature range at which a molten metal can crystallize and the presence of various types of radiations. Let us dwell briefly on the possibility of simulating each of these factors.

Our research showed that the best simulation of a space vacuum is achieved when working in large vacuum chambers, the dimensions of which, generally, are determined by the dimensions of the equipment to be tested. This is also true for simulating temperature conditions and radiation effects.

Simulation of these factors somewhat deteriorates when working in small vacuum chambers. Nevertheless, a satisfactory simulation can be achieved in these conditions, remembering that one must take into account the clearly expressed direction of the simulated magnitudes which are in effect. Normally, satisfactory simulation of the effect of these factors can be obtained on only one or two axes.

It is much more difficult to simulate weightlessness. Methods used for the ground training of cosmonauts, for example, in a weightlessness basin, are unsuitable for working with molten metal. The best conditions for simulating weightlessness when carrying out research of technological processes are achieved in an airborne laboratory. But this method also has its faults, the main ones being the short duration of weightlessness and the limited ... [several words missing] ... equipment.

As can be seen, requirements for the simultaneous simulation /3
of the effects of all these factors in space are clear contradictions of possibilities existing today. Therefore, in this work, we were forced to carry out gradual study of the effects of space on technological processes, some of which was done on earth in large thermal vacuum chambers, some in an airborne laboratory, in vacuum test stands specially built for this purpose.

At first, a stand for carrying out technological experiments in the airborne laboratory was developed at the Institute of Electric Welding im. Ye.O. Paton at the Academy of Sciencies of Ukrainian Soviet Socialist Republic in 1965. When developing this test stand, the problem had to be solved of simulating basic space factors -- a high vacuum and, in combination with the airborne laboratory, weightlessness when carrying out process automatically. The vacuum chamber of the test stand is small (about 100 ℓ) and is in the shape of a cylindrical vessel made from stainless steel with a spherical bottom and a hinged lid (Fig. 1). The case of the chamber has a neck which connects to a high-vacuum exhaust unit, a vacuum valve, a hermetic intake with a magnetic coupling for transmitting the stage rotation within the chamber and a row of windows for visual observation and films.

The hinged lid of the chamber has a neck with a bellows adjuster for regulating various sources of cathode ray, plasma or arc heating, with a power of approximately 1 kW, which makes it possible to weld, cut, solder, spray coat metal and fuse small pieces of metal.

A parabolic mirror can be used instead of a hinged lid, which,
in conjunction with a powerful arc lamp, simulates concentrated /4
solar energy for these technological processes.

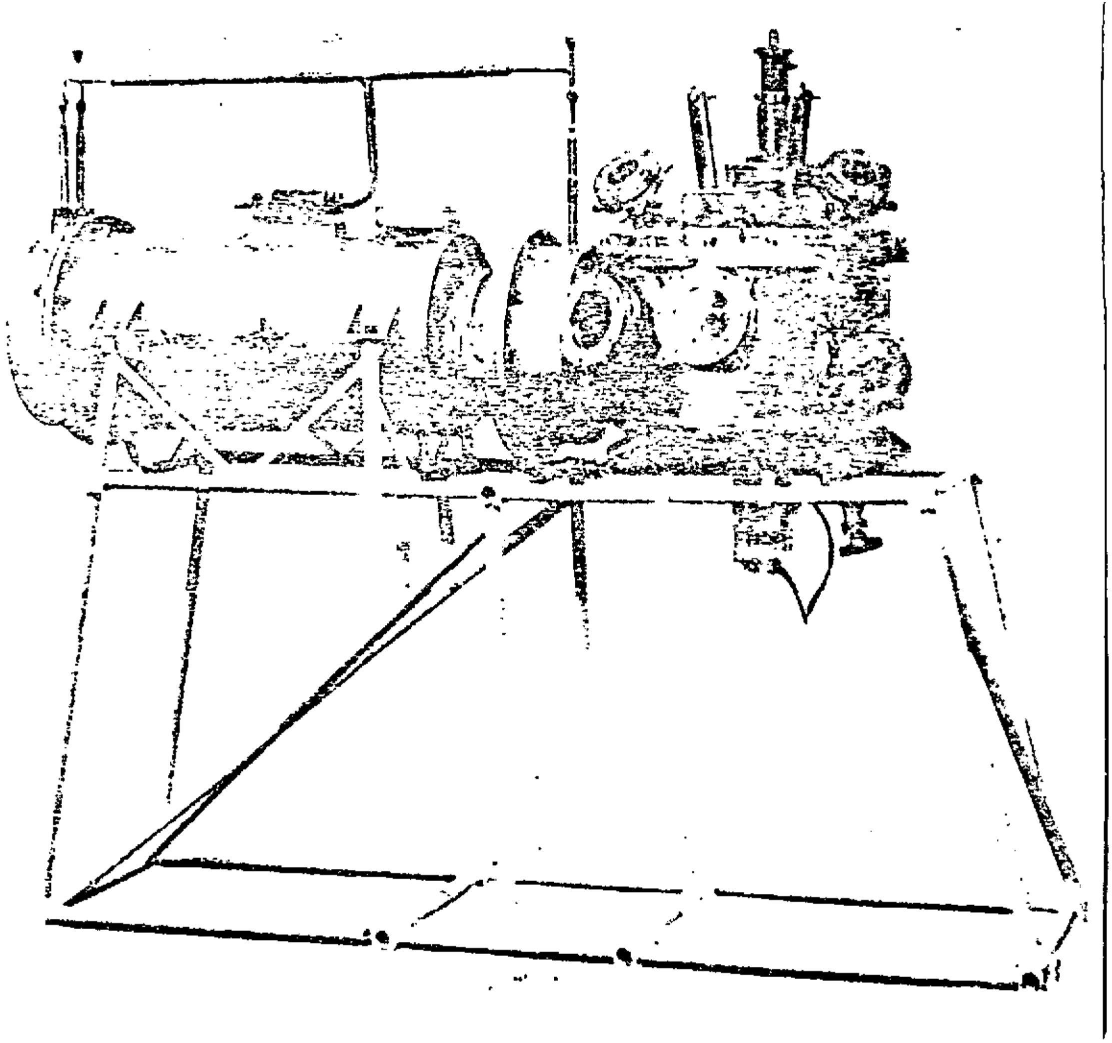

Fig. 1.

Each piece of equipment is very small and can work reliably in a vacuum.

At the bottom of the chamber (Fig. 2) is a microscope stage, where samples of processed material can be placed and moved.

A special vacuum exhaust system must be used to create and maintain the required vacuum pressure in the working chamber; it consists of a preliminary exhaust unit and a sorbtion high-vacuum getter exhaust assembly, which can operate in weightlessness. The ultimate vacuum of the assembly is $(1\text{-}3)\cdot 10^{-7}$ torr.

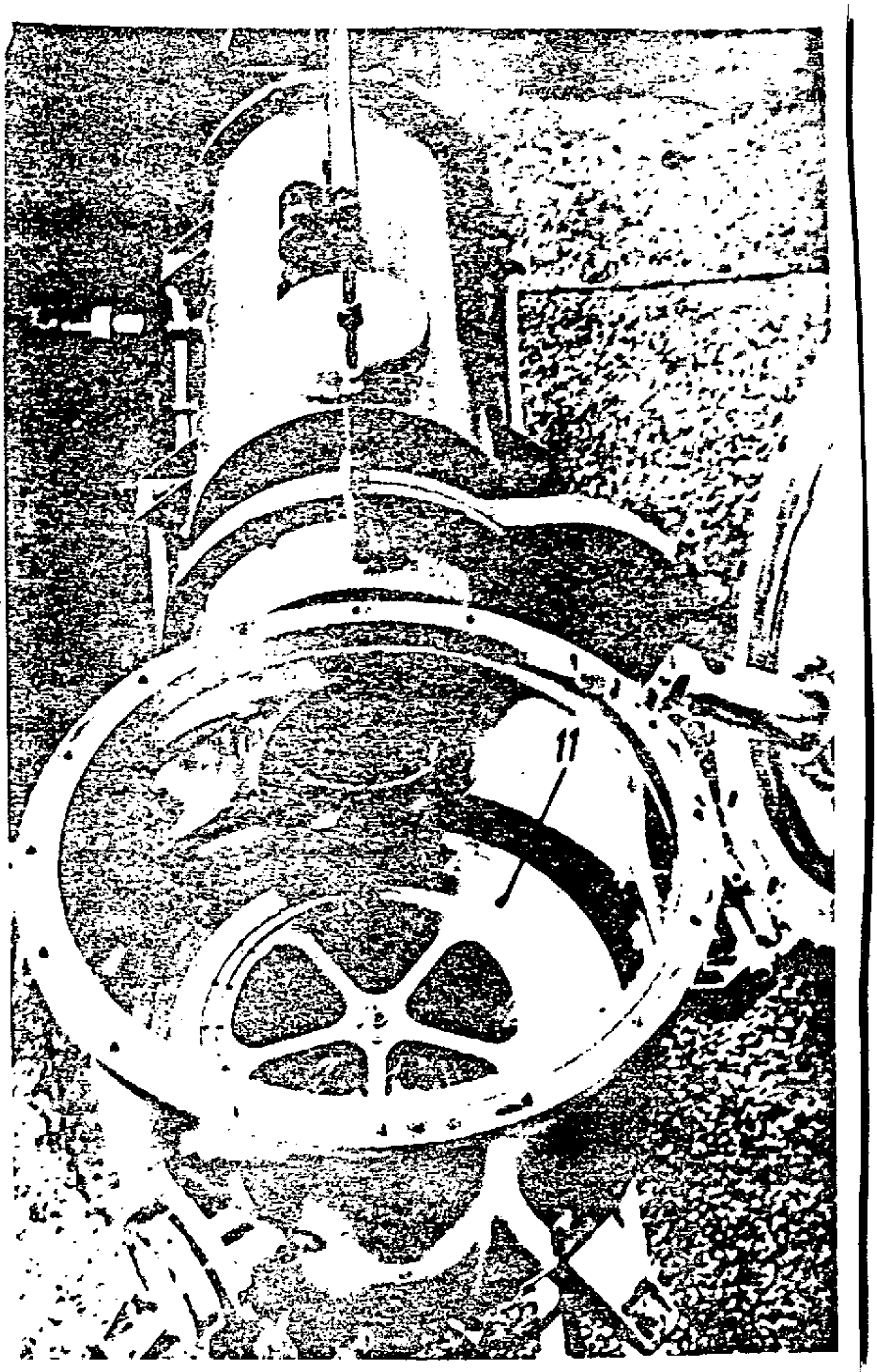

Fig. 2.

During the experiment in the working chamber, the pressure was maintained, depending on conditions for carrying out the experiment, in the ranges of $5 \cdot 10^{-5}$ - 10^{-6} torr. During work, the high-vacuum assembly did not require electrical energy, which is a great advantage in an airborne laboratory.

The progress of the experiments was recorded by special apparatus, including a 12-channel oscillograph and three film cameras (a normal one, with a photographic speed of 24 frames per second, on a 35 mm film and two high-speed cameras, with a photography speed of 300-5000 frames per second, on 16 mm film). Scale marks and time marks, recorded synchronously on an oscillogram and cinema film, made it possible to carry out coordination and time analysis in the working area.

Control of the test stand was done automatically to reduce the work done by the operator in flight. When conducting an experiment, the operator only carries out the initial switching on of the equipment and the high-speed cameras; the remaining operations are done automatically.

The siting of the test stand in the passenger compartment of airborne laboratory (Fig. 3) is determine by the specific conditions for conducting the experiment. The overal dimensions of the test stand, set up in the passenger compartment, are 200 × 1450 × 1300 mm, the weight of the test stand is 500 kg. /5

The test stand made it possible to carry out a whole range of important investigations; the basic regularities for automatic welding and cutting of various strip metals in a vacuum and weightlessness were studied, it was proved that, in principle, it is possible to fuse small amounts of metal in these conditions and spray coat metals by using heat sources described above.

However, research carried out did not give the answer to the question on whether an operator in a full-pressure suit could carry out in space such technologically complicated operations as assembly, welding, soldering and cutting different structures.

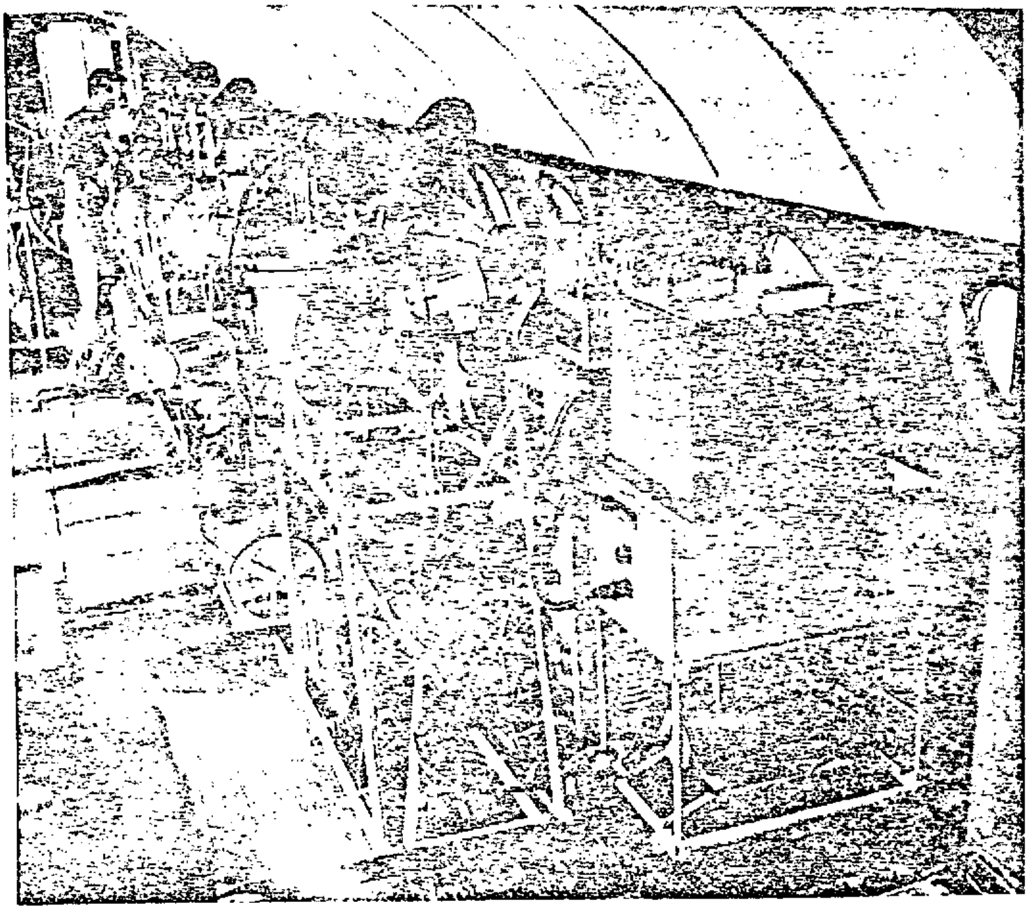

Fig. 3.

Experiments on the ground showed that it was possible to perform similar operations in a full-pressure suit, but normal instruments were unsuitable. It was also found that when working in a full-pressure suit, there are excessively high demands for ergonomics and the siting of working areas. In other words, to develop equipment and technology to carry out these operations manually, one requires a large amount of research and prolonged, meticulous operator training. This requires numerous expensive experiments in the airborne laboratory and the use of a whole range of life support systems in the high-pressure suit.

The problem can be made much easier by producing special test stand simulators.

A test stand simulator of this type for developing welding equipment and training operators was developed and produced at the Institute of Electric Welding im. Ye. O. Paton of the Academy of Sciences of the Ukrainian Soviet Socialist Republic (Fig. 4).

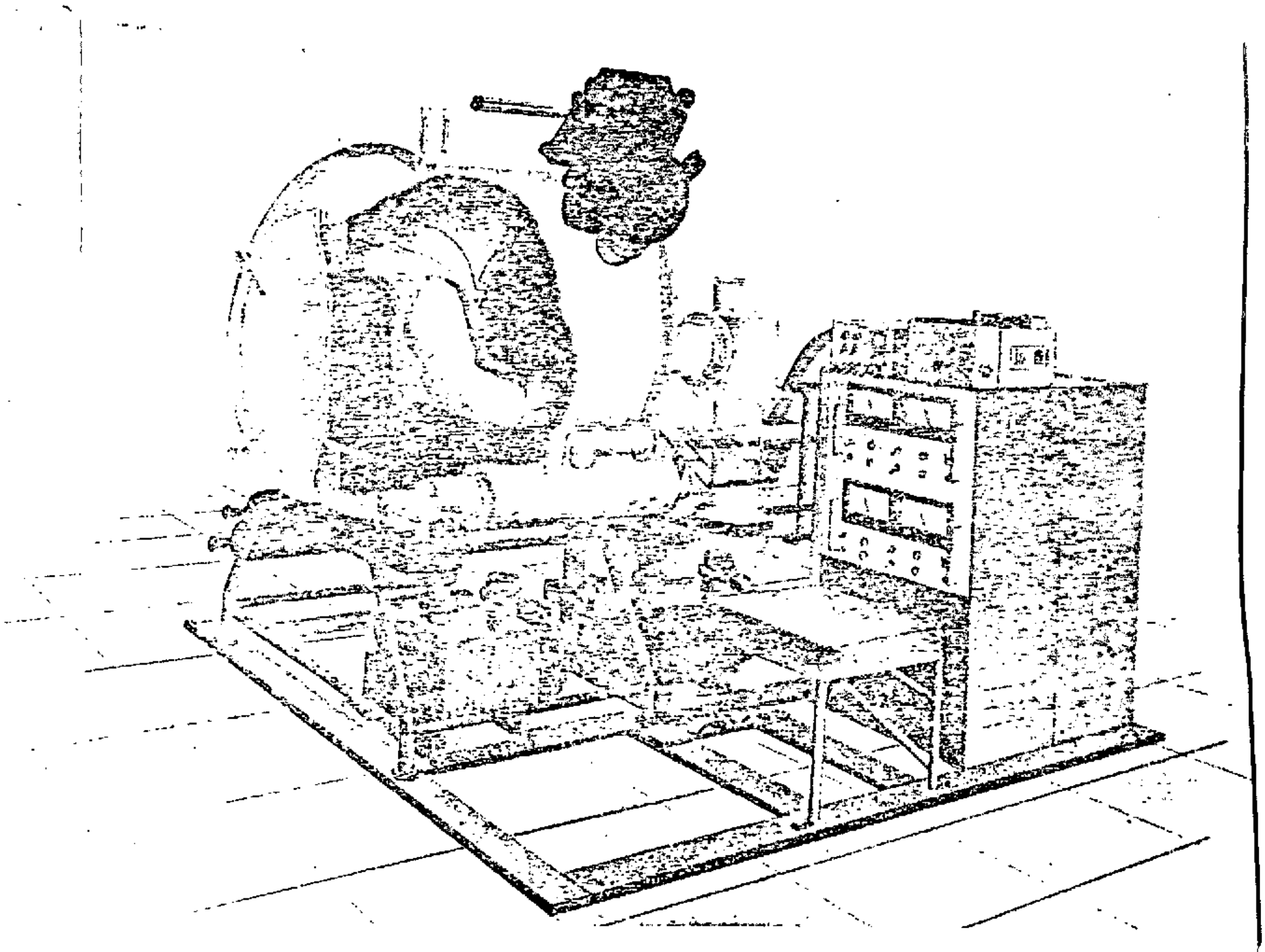

Fig. 4.

The test stand, set up in the airborne laboratory, makes it possible to investigate the methods and techniques of carrying out various operations by manual instruments and equipment in a full-pressure suit in weightlessness conditions. /6

The sealed working chamber of the test stand, with observation and film windows, has a volume of slightly more than 0.8 m^3, and quite large objects for investigation can be placed in it. The construction of the test stand and the functions of the exhaust equipment make it possible to increase the volume of the chamber by installing additional sections.

In order to carry out manual operations, part of a space suit is fixed onto the front wall of the work chamber, so that any required fall of pressure can be introduced, simulated actual operator working conditions.

The transparent paneling of the suit's helmet has a set of interchangeable filters, so that work can be done on objects of different brightness.

If automatic equipment is placed in the work chamber, part of the full-pressure suit is dismantled, and the front wall is covered with a sealed hatch with high-speed clamps.

The vacuum extraction system used in the test stand is similar to the one described earlier, but has a higher performance.

An operator and his assistants take part in the experiments on the test stand. The assistants' functions include controlling from the test stand console the exhaust unit, the system for filling the chamber with gas and the recording apparatus -- the normal and high-speed cine cameras, lamps and the multichannel oscillograph.

The operator's task is to work directly with the object being investigated. The test stand makes it possible to work with a heat source of up to 3 kW.

One significant advantage of the test stand described is the /7
fact that a medical and biological check of the operator, working in a part of the full-pressure suit, can be made, and the fact that it is convenient to carry out various ergonomic investigations.

Experience in its operation proved that the test stand is a general-purpose research facility enabling large numbers of experiments to be conducted, and an effective simulator for training operators, when carrying out all types of technological welding, fitting and mounting.

The use of the described test stands greatly simplifies and shortens the process for preparing technological experiments on space objects and operator training.